

SECTION 32

SIGN SUPPORT STRUCTURES (OVERHEAD AND CANTILEVER)

1.32.1 GENERAL DESIGN CRITERIA

- a. Designs shall be in accordance with the current AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals and the current AASHTO Standard Specifications for Highway Bridges with the following modifications:

Article 1.1.3 - FUNCTIONAL REQUIREMENTS

- (A) Vertical Clearance for Overhead Sign Support Structures.

Minimum vertical underclearance for overhead and cantilever sign support structures shall be 5.4 meters as specified on Standard Plates 2.8-2 and 2.10-2 and also in Subsection 1.3.1 of this Manual.

Article 1.2.4 WIND LOAD

The design wind velocity shall be 129 kilometers per hour.

Article 1.5.2 - ALLOWABLE UNIT STRESS

The allowable stresses to be utilized for aluminum alloy members shall be in accordance with Appendix A of the current Aluminum Association's Publication 30, Specification for Aluminum Structures entitled Allowable Stresses for Bridge and Similar Type Structures.

- b. Fatigue Resistance

Fatigue is a complex phenomenon that is governed by factors that are highly variable and difficult to quantify. The provisions of the AASHTO Standard Specifications for Highway Bridges for structural fatigue design are based upon a nominal stress approach in which details are grouped into categories according to their relative fatigue resistance. Each category possesses a maximum stress range below which fatigue is obtained.

The stress range resulting from application of the above fatigue loads shall be less than the stress range for the particular detail. Most common details are categorized in Section 10.3 of the AASHTO Standard Specifications for Highway Bridges. The maximum stress range for these details is tabulated as the fatigue strength for greater than two-million cycles. The fatigue limit for details on tubular connections is given in AWS D1.1 Structural Welding Code - Steel.

- c. For Overhead Sign Support Structures, see Standard Design Plates 2.8-1 to 12.8-11 to obtain design information and instructions for developing Standard Plan Sheets 2.9-1 to 2.9-10 as contract plans.

- d. For Cantilever Sign Support Structures, see Standard Design Plates 2.10-1 to 2.10-5 to obtain design information and instructions for developing Standard Plan Sheets 2.11-1 to 2.11-7 as contract plans.
- e. See Section 33 of this Manual for criteria concerning Bridge Mounted Sign Support Structures.

1.32.2 VARIABLE MESSAGE SIGN (VMS) SUPPORT STRUCTURES

- a. The design of Overhead and Cantilever sign support Variable Message Sign (VMS) structures shall conform to the following publications:
 - AASHTO Standard Specifications for Highway Bridges, with current interims.
 - Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 1994, with current interims.
 - American Welding Society - Structural Welding Code - Steel (Current Edition)
- b. Initially, the NJDOT Standard Overhead and Cantilever Sign Support Drawings may be used for member selection. In accordance with the guidance provided in the first bullet item of part c. below, the greatest sign area shall be used for the structure selection. A fatigue analysis shall be performed to determine adequate member sizes using three dimensional modeling. For Cantilever VMS sign structures, all joints shall be assumed to be rigid.
- c. The following guidance shall be followed in designing and developing contract documents for the construction of VMS sign structures:
 - To accommodate the potential future placement of fixed message signs, the minimum vertical underclearance, that is to be considered for the placement of the VMS board, shall be 8 meters to the centerline of the truss. This is considerate of a fixed message sign design height of 4.6 meters and the 5.4 meter minimum vertical underclearance to the lower limit of the maintenance walkway.
 - VMS boards shall be centered vertically between the upper and lower truss chord members.
 - The horizontal distance from the centerline of the truss chords to the center of gravity of the VMS board shall be minimized.
 - VMS sign support structures shall be designed to accommodate one VMS board only. A note to this effect shall be provided in the General Notes portion of the contract plans.
 - Fixed message signs, on a project to project basis, will be permitted on Overhead VMS sign support structures only. Accordingly, the General Notes for overhead VMS sign support structures shall indicate the sign area for

- A maintenance walkway, to the location of the VMS board access panel only, may be provided.

- One possible method that may be used to determine design forces would be to load the sign structure model to theoretical failure, as determined by the chords and posts, and designing the strut to chord connections based upon the forces in the strut at that load.

For the chord:

- Category D (Transition > 51 mm)
- Category E (Transition ≤ 51 mm)

- For the cantilever VMS sign structure, all three phenomena shall be applied. For the overhead VMS sign structure, the natural wind gusts and truck induced gusts phenomena need only be applied.

- For cantilever VMS sign structures, truck induced gusts shall be applied to the full length of the bottom face of the VMS board, and to the projected area of the bottom chord, the walkway and any miscellaneous attachments that are exposed to the roadway below. Wind forces acting on truss members that are beyond the bottom face of the truss are not to be accounted for.

- For overhead VMS sign structures, truck induced gusts shall be applied to the middle 11 meter length of the truss. This will include the full length of the bottom face of the VMS board, to the projected area of both bottom chords, the bottom diagonals and the bottom struts, the walkway, and to any miscellaneous attachments that are exposed to the roadway below. Wind forces acting on truss members that are beyond the bottom face of the truss are not to be accounted for.

- Gusset plates should be designed for actual bending stresses and checked against allowable stresses.

Sign Support Structures (Overhead and Cantilever)

- All chord splices are to be designed in accordance with AASHTO criteria. As such, the chord splices and stub to post connections shall be designed for the average of the actual and allowable stresses in the chords, but not less than 75% of the member's capacity.
- e. Upon completion of the initial fatigue analysis, if member sizes are determined to be inadequate, new sizes shall be selected and a new analysis shall be made. In performing the analysis, the following guidance may be applied:

1). General Design

VMS sign support structures should be designed for deflection and strength using the load combinations in accordance with the Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, including dead load plus maximum wind load.

2). Vibration and Fatigue Design

In addition to the strength design, all structural details must be checked for fatigue resistance, computing nominal stress ranges at the details, and assuring that the stress ranges are less than the constant-amplitude fatigue limits for the particular details. This should ensure an essentially infinite life.

3). Fatigue Loads

Four wind loading phenomena (vortex shedding, galloping, natural wind gusts, and truck-induced wind gusts), have been identified in causing large-amplitude vibrations and fatigue failure in sign, signal and luminaire support structures.

As overhead support structures are far less flexible, only natural wind gusts and truck-induced wind gusts are applicable to overhead sign structures.

The primary concern in the design of cantilevered VMS structures is the galloping loading phenomenon. Therefore, for cantilever VMS structures, galloping, natural wind and truck induced wind gusts are applicable.

4). The following fatigue loads shall be applied in analyzing VMS sign structures for fatigue resistance:

a.) Natural Wind Gusts

Overhead and cantilever VMS sign support structures shall be designed to resist an equivalent natural wind gust pressure range of the following:

$$P_{NW} = 250 C_d \text{ (Pascal)}$$

where C_d is taken as the drag coefficient for various shaped

surfaces of the structures.

The drag coefficient shall be taken from Table 1.2.5C of the Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. The appropriate drag coefficient for the various shaped surfaces of the structure shall be used.

This natural wind gust pressure range shall be applied in the horizontal direction to the area projected on a vertical plane of all support structure members and the VMS board.

b.) Truck-Induced Gusts

Overhead and cantilever VMS sign support structures shall be designed to resist an equivalent static truck induced gust pressure range of the following:

$$P_{TG} = 1760 C_d \text{ (Pascal)}$$

where C_d shall be the drag coefficient specified in Table 1.2.5C of the Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. The appropriate drag coefficient for the various shaped surfaces of the structure shall be used.

Refer to the guidance provided under item 3. above for direction as to the limits that should be followed in applying the truck induced gusts to both type VMS sign structures.

c.) Galloping Induced Gusts

Additionally, cantilevered VMS support structures shall be designed to resist an equivalent static galloping traction range of the following:

$$P_{GG} = 1000 \text{ (Pascal)}$$

This equivalent static traction range should be applied vertically, as a shear stress, on the frontal surface area of all sign attachments that are mounted to the horizontal mast arm.

5). Deflection Criteria

For the overhead support structures, the maximum deflection shall be limited to 1/480 of the span length.

For the cantilever support structures, each applicable wind load range described above should be applied separately and the largest vertical or horizontal deflection range should be limited to 200 mm.

The 200 mm range is defined as the sum of the potential upward and downward or potential horizontal axis displacement of the cantilever structure.

This criteria is included to minimize potential vibration damage to the

VMS, ensure motorist visibility, and to reduce motorist concerns.

1.32.3 HIGH STRENGTH BOLTED CONNECTIONS

- a. Specifications contained in Section 509 of the NJDOT Standard Specifications for Road and Bridge Construction, concerning installation of sign structures, shall be adhered to in developing contract documents.
- b. Sign Structure bolt connections shall be installed in accordance with the criteria stated in Subsection 11.5.6.4 of the AASHTO Standard Specifications for Highway Bridges, Division II.

In accordance with the AASHTO Specifications, when calibrated wrenches are used for bolt installations, they shall be set to provide a tension that is not less than five (5) percent of the minimum tension that is specified in the following Table:

Required Fastener Tension - Minimum Bolt Tension In Kilonewtons*

Metric Bolt Size	AASHTO M 164M ASTM A 325M	AASHTO M 253M ASTM A 490M
M16	84.5	106.8
M20	124.6	155.7
M22	173.5	218.0
M24	226.9	284.7
M27	249.1	355.9
M30	315.8	453.7
M36	458.2	658.3

* Equal to 70% of the bolt material's ultimate strength (as specified in ASTM specifications for tests of full-size A 325M and A 490M bolts with UNC threads loaded in axial tension) rounded to the nearest kilonewton.

- c. For bolt sizes that are greater in size than those provided in the above Table, a calculation shall be performed to determine the proper torque that should be applied to bring such bolts to a fully tighten condition.

As stated above, the minimum bolt tension is equal to 70% of the bolt material's ultimate strength. The following formulas may be used to derive the required torque value for bolt assembly installations:

$$F_1 = 0.7 \times F_u \times A_T \quad \text{where "F}_1\text{" is the bolt minimum tension "F}_u\text{" is the ultimate strength and "A}_T\text{" is the tensile stress area}$$

$$A_T = \frac{\pi}{4} (d - 0.938P)^2 \quad \{ \text{mm}^2 \} \quad \text{where "d" is the bolt diameter in the unthreaded portion, "n" is the number of threads per millimeter and "P" is the thread pitch}$$

$$F_1 = \frac{T}{K \times d} \quad \text{where "T" is the torque and "K" is a friction coefficient depending on thread lubrication}$$

The third formula may be used to derive the required torque for the bolt sizes listed in the above Table. As a worst case, a value of 0.2 may be used for "K".

- d. The calculated values for those bolts that are to be used in the installation of all sign support structures shall be indicated in the General Notes of such contract drawings.

1.32.4 FOUNDATION

- a. At least one boring for each footing location is required (see Section 36).
- b. Foundation conditions may require pile types other than those indicated on the Standard Drawing Plates. In such a case, the Standard Contract Plan Plates shall be modified accordingly. A foundation report shall be included in the Preliminary plan submission in any case (see Section 36). This report can simply state, when warranted, that a study of the borings confirm that footings indicated on the Standard Plates are satisfactory for use in the design without any changes.
- c. Subsurface utilities which cannot be relocated, or other special conditions, may require individual footing designs.
- d. Acquisition of property is sometimes a long term process. Footings should be redesigned on an individual basis if taking of property outside of right of way can be avoided.
- e. Top of concrete pedestals shall not project higher than 100 millimeters above finished ground line.
- f. Footing designs should be provided in the furnishing of contract drawings for VMS structures.
- i. Refer to item 1.16.19 of this Manual for guidance concerning bottom of footing locations.

1.32.5 PLAN SUBMISSIONS

- a. Bridge sketch plans 210 by 297 millimeters (see Section 6) shall be submitted for approval of geometrics prior to Preliminary Plan Submission.
- b. Preliminary bridge plans will be required for sign support structures in accordance with Section 7. This submission shall include: Key Plan to Structures, Elevation of Structures, Foundation Report and Boring Logs and Estimated Construction Cost.
- c. If changes are made on any of the Standard Contract Plan Plates to suit the conditions of a particular project, such as the foundation, then half-size copies of those plates that were changed, shall be included with the Preliminary plan submission. Changes shall be indicated in red.

- d. Shop drawings to be prepared by the contractor and approved by the Designer are required by the contract specifications.

1.32.6 STANDARD DRAWINGS

- a. Mylar reproductions (594 by 841 millimeters) of the Standard Contract Plan Plates are available without charge for use on a contract to contract basis. They may be obtained from the Engineering Documents Unit of the Bureau of Quality Management Services. Telephone: 609-530-5587.
- b. No changes in design criteria or details shall be made on the standard drawing and plan plates without prior authorization except as permitted in Subsections 1.32.3 c. and 1.32.4 c.
- c. The Design Unit will be advised during the Preliminary stage of locations where the sign panels are to be of the 100% reflectorized area type. At such locations, the external lighting system and the maintenance walkway may be omitted. Otherwise, when sign lighting is deemed necessary, a lighting system, such as the Lumi-Trak Sign Lighting system, may be used.

These decisions will be made on a project to project basis by the Traffic Signal and Safety Engineering Unit of the Bureau of Design and Engineering Support. Locations selected depend on roadway geometrics, sight distance etc.

The Design Unit shall make the necessary changes to the standard contract plans for the structures designated prior to submission of Final Plans. The vertical underclearance shall remain as prescribed on Standard Drawing Plates 2.8-2 and 2.10-2.

- d. For the permanent record, the design calculations submitted at the Final Submission shall include a list of the Standard Design Instruction Drawings (Plates 2.8-1 to 2.8-11 for overhead sign structures and Plates 2.10-1 to 2.10-5 for cantilever sign structures) used in preparing the contract plans.
- e. The provision of maintenance walkways is not required for overhead and cantilever sign structures. If provision of a maintenance walkway is otherwise warranted, approval for its installation shall be obtained from the Manager, Bureau of Structural Engineering.

1.32.7 STRUCTURE NUMBERS

Structure numbers (7 digit) for the individual sign structures will be assigned during the Final plan review (similar to the structure numbers for bridges as per Section 40). Temporary identification numbers used during the design phase shall be changed accordingly in the tabulations and contract pay items.

1.32.8 GENERAL

- a. Overhead and cantilever sign support structures located on a bridge superstructure should not be located in areas where they will be subject to the vibrations caused by live load deflections of the superstructure. Tower shaft base plates shall be located directly on the substructure units if compatible with

design and details.

Special support details shall be considered for any other case.

- b. Support structures that are required to support Variable Message Sign structures are subject to loading conditions that were not anticipated in the development of the overhead and cantilever sign support structures standard drawings. The Designer is required to perform additional analysis for dynamics that such structures will be subjected to while in service. Refer to 1.32.2 above for guidance.
- c. In the furnishing of sign panels for overhead and cantilever sign support structures, the size of the panels shall be such that the panel shall project a minimum of 150 mm above and below the respective top and bottom chord.
- d. As stated on the Standard Drawings, where appropriate, alternate Foundation Designs for both overhead and cantilever sign structures may be considered.

When alternate Foundation Designs, such as drilled shafts, are considered, the Tables on pages 1.32-11 through 1.32-14 for Overhead Sign Supports and page 1.32-16 for Cantilever Sign Supports should be referred to for application of loads.

- e. The proposed approximate quantities for Foundation Excavation, Concrete in Structures, Footings and Reinforcement Steel in Structures shall reflect the summation of, respectively, all the overhead and cantilever sign structures that are within a contract.

Each sign support structure shall be listed individually in numerical order for each type that is in a contract. Refer to Subsection 1.32.7 for assigning of structure numbers.

Contract Pay Items for Lighting and Electrical work are usually included with the Roadway Items of work.

TABLE 32.1
OVERHEAD SIGN SUPPORT
LOADS AT BOTTOM OF BASEPLATE

SS (%)	span (m)	height (m)	Pdl,max (kN)	Pdl,min (kN)	Pwind (kN)	Pice.max (kN)	Pice.min (kN)	Hwind (kN)	Ht,wind (kN)	Mt,wind (kN-m)
40%	15.00	8.00	19.24	10.65	137.21	11.77	1.76	17.97	2.68	21.44
60%	15.00	8.00	20.68	10.86	189.19	12.63	1.89	24.39	3.78	30.22
70%	15.00	8.00	21.39	10.97	216.86	13.06	1.95	27.81	4.36	34.89
80%	15.00	8.00	22.10	11.08	243.07	13.49	2.02	31.05	4.91	39.31
40%	15.00	10.00	20.68	12.08	174.09	12.09	2.07	23.17	2.68	26.80
60%	15.00	10.00	23.23	13.70	234.85	12.99	2.56	31.87	3.78	37.77
70%	15.00	10.00	23.93	13.82	268.44	13.41	2.63	36.16	4.36	43.61
80%	15.00	10.00	24.64	13.93	300.24	13.83	2.70	40.22	4.91	49.14
40%	15.00	12.00	23.51	15.17	209.70	12.50	2.78	27.69	2.68	32.16
60%	15.00	12.00	24.93	15.40	285.40	13.35	2.92	36.76	3.78	45.32
70%	15.00	12.00	27.01	17.08	318.19	14.06	3.47	41.21	4.36	52.33
80%	15.00	12.00	27.71	17.20	355.67	14.48	3.54	45.78	4.91	58.97
40%	18.00	8.00	21.69	11.37	162.37	13.80	1.78	21.08	3.21	25.69
60%	18.00	8.00	23.40	11.62	226.53	14.83	1.93	29.01	4.57	36.52
70%	18.00	8.00	24.26	11.75	258.04	15.35	2.01	32.90	5.23	41.84
80%	18.00	8.00	25.91	13.06	282.94	15.81	2.44	37.22	5.89	47.16
40%	18.00	10.00	23.12	12.80	205.54	14.11	2.09	27.07	3.21	32.11
60%	18.00	10.00	25.92	14.49	280.17	15.16	2.63	37.66	4.57	45.65
70%	18.00	10.00	26.77	14.62	318.41	15.66	2.72	42.54	5.23	52.30
80%	18.00	10.00	28.72	16.10	349.07	16.37	3.23	47.13	5.89	58.95
40%	18.00	12.00	25.93	15.91	246.34	14.49	2.83	32.08	3.21	38.53
60%	18.00	12.00	28.99	17.76	332.02	15.79	3.49	42.89	4.57	54.78
70%	18.00	12.00	29.84	17.91	377.08	16.29	3.57	48.39	5.23	62.76
80%	18.00	12.00	31.99	19.72	413.52	16.90	4.14	54.62	5.89	70.74
40%	21.00	8.00	24.05	12.00	187.29	15.79	1.77	24.16	3.74	29.90
60%	21.00	8.00	26.05	12.30	262.31	16.99	1.95	33.43	5.32	42.56
70%	21.00	8.00	28.27	14.20	290.80	17.59	2.60	38.49	6.11	48.90
80%	21.00	8.00	29.25	14.37	326.10	18.18	2.70	43.01	6.88	55.08
40%	21.00	10.00	26.57	14.87	232.55	16.10	2.49	31.58	3.74	37.37
60%	21.00	10.00	28.54	15.19	323.58	17.28	2.69	43.20	5.32	53.20
70%	21.00	10.00	31.07	17.25	358.75	18.13	3.41	48.73	6.11	61.12
80%	21.00	10.00	32.05	17.42	402.09	18.72	3.52	54.40	6.88	68.85
40%	21.00	12.00	28.27	16.57	282.64	16.46	2.85	36.43	3.74	44.84
60%	21.00	12.00	32.91	20.17	375.64	17.99	4.05	49.87	5.32	63.84
70%	21.00	12.00	34.33	20.90	424.85	18.65	4.34	56.42	6.11	73.34
80%	21.00	12.00	35.30	21.08	475.43	19.23	4.45	62.81	6.88	82.62
40%	24.00	8.00	27.18	13.53	214.30	17.98	2.07	27.70	4.34	34.73
60%	24.00	8.00	30.81	15.79	289.39	19.33	2.88	38.58	6.13	49.02
70%	24.00	8.00	31.91	15.96	329.15	20.01	3.00	43.71	7.00	56.03
80%	24.00	8.00	33.03	16.15	368.92	20.67	3.11	48.85	7.88	63.05
40%	24.00	10.00	29.68	16.42	265.35	18.26	2.82	36.01	4.34	43.41
60%	24.00	10.00	33.58	18.83	357.05	19.87	3.71	48.84	6.13	61.27
70%	24.00	10.00	34.70	19.03	405.87	20.54	3.83	55.27	7.00	70.04
80%	24.00	10.00	38.59	22.00	454.70	21.20	3.94	61.71	7.88	78.81

TABLE 32.1
OVERHEAD SIGN SUPPORT
LOADS AT BOTTOM OF BASEPLATE

SS (%)	span (m)	height (m)	Pdl,max (kN)	Pdl,min (kN)	Pwind (kN)	Pice.max (kN)	Pice.min (kN)	Hwind (kN)	Ht,wind (kN)	Mt,wind (kN-m)
40%	24.00	12.00	32.74	19.72	314.58	18.86	3.70	41.04	4.34	52.09
60%	24.00	12.00	36.84	22.49	422.91	20.37	4.65	56.54	6.13	73.52
70%	24.00	12.00	37.94	22.70	479.89	21.03	4.78	63.79	7.00	84.05
80%	24.00	12.00	42.83	26.70	536.87	21.68	4.90	71.04	7.88	94.57
40%	27.00	8.00	30.96	15.71	242.47	20.35	2.60	31.42	4.97	39.77
60%	27.00	8.00	35.90	19.25	323.51	22.02	3.80	43.62	6.98	55.84
70%	27.00	8.00	37.15	19.47	366.51	22.78	3.94	49.25	7.94	63.54
80%	27.00	8.00	39.23	20.84	401.69	23.61	4.49	54.71	8.91	71.26
40%	27.00	10.00	33.64	18.83	299.63	20.67	3.42	40.70	4.97	49.71
60%	27.00	10.00	38.70	22.34	398.98	22.54	4.64	55.15	6.98	69.80
70%	27.00	10.00	40.99	24.09	441.80	23.29	5.29	62.78	7.94	79.43
80%	27.00	10.00	42.22	24.34	493.30	24.03	5.43	69.86	8.91	89.08
40%	27.00	12.00	36.71	22.16	354.97	21.26	4.32	46.31	4.97	59.65
60%	27.00	12.00	41.96	26.04	472.01	23.03	5.61	63.66	6.98	83.76
70%	27.00	12.00	47.02	30.11	533.68	23.77	5.76	71.62	7.94	95.32
80%	27.00	12.00	48.25	30.36	595.48	24.50	5.91	79.60	8.91	106.90
40%	30.00	8.00	36.49	20.27	262.77	22.71	3.84	35.65	5.62	44.96
60%	30.00	8.00	39.27	20.77	358.39	24.38	4.13	48.19	7.76	62.09
70%	30.00	8.00	43.31	24.28	394.35	25.52	5.25	54.52	8.87	70.99
80%	30.00	8.00	46.99	26.85	450.44	26.34	5.41	62.11	10.17	81.37
40%	30.00	10.00	38.20	21.98	331.34	23.07	4.20	45.46	5.62	56.20
60%	30.00	10.00	43.10	25.40	432.09	24.87	5.51	61.44	7.76	77.61
70%	30.00	10.00	46.31	27.79	484.50	25.93	6.20	69.61	8.87	88.74
80%	30.00	10.00	50.91	31.31	552.73	26.75	6.37	79.13	10.17	101.71
40%	30.00	12.00	42.56	27.05	384.92	23.70	5.66	52.42	5.62	67.44
60%	30.00	12.00	49.12	31.43	522.03	25.34	5.99	70.12	7.76	93.13
70%	30.00	12.00	52.34	33.82	584.87	26.41	6.68	79.32	8.87	106.49
80%	30.00	12.00	56.02	36.93	646.90	27.36	7.51	89.42	10.17	122.05
40%	33.00	8.00	38.76	20.94	286.58	24.59	3.83	38.77	6.15	49.22
60%	33.00	8.00	44.76	25.06	381.73	26.78	5.21	52.81	8.58	68.66
70%	33.00	8.00	48.57	27.65	442.14	27.69	5.39	60.99	9.98	79.83
80%	33.00	8.00	54.55	33.00	483.55	29.08	6.66	68.36	11.24	89.91
40%	33.00	10.00	41.55	24.04	353.62	25.09	4.69	49.08	6.15	61.53
60%	33.00	10.00	47.75	28.57	469.14	27.17	6.18	67.47	8.58	85.82
70%	33.00	10.00	52.48	32.12	542.63	28.08	6.37	77.72	9.98	99.79
80%	33.00	10.00	58.47	37.48	593.07	29.47	7.63	86.97	11.24	112.39
40%	33.00	12.00	44.79	27.76	419.05	25.54	5.69	56.82	6.15	73.84
60%	33.00	12.00	53.78	34.60	566.44	27.65	6.66	76.90	8.58	102.98
70%	33.00	12.00	57.58	37.75	635.10	28.68	7.53	87.83	9.98	119.75
80%	33.00	12.00	63.59	43.13	694.49	30.08	8.80	98.25	11.24	134.87
40%	36.00	8.00	45.09	26.26	306.14	27.20	5.27	42.57	6.83	54.67
60%	36.00	8.00	53.28	32.36	410.33	29.71	6.82	58.20	9.50	76.03
70%	36.00	8.00	57.22	35.00	472.99	30.69	7.02	66.92	10.99	87.94
80%	36.00	8.00	58.85	35.34	526.57	31.68	7.23	74.38	12.27	98.13

TABLE 32.1
OVERHEAD SIGN SUPPORT
LOADS AT BOTTOM OF BASEPLATE

SS (%)	span (m)	height (m)	PdI,max (kN)	PdI,min (kN)	Pwind (kN)	Pice,max (kN)	Pice,min (kN)	Hwind (kN)	Ht,wind (kN)	Mt,wind (kN-m)
40%	36.00	10.00	47.06	28.22	385.27	27.63	5.70	54.08	6.83	68.34
60%	36.00	10.00	56.27	35.89	504.17	30.10	7.80	74.24	9.50	95.04
70%	36.00	10.00	61.13	39.49	580.46	31.07	8.02	85.16	10.99	109.93
80%	36.00	10.00	62.74	39.84	645.69	32.04	8.23	94.51	12.27	122.66
40%	36.00	12.00	50.29	31.96	456.09	28.07	6.72	62.45	6.83	82.01
60%	36.00	12.00	60.31	40.45	590.52	30.70	8.97	83.90	9.50	114.50
70%	36.00	12.00	66.24	45.15	679.75	31.66	9.19	96.21	10.99	131.92
80%	36.00	12.00	67.84	45.52	756.03	32.63	9.42	106.74	12.27	147.19
40%	39.00	8.00	53.46	33.59	330.83	29.91	6.79	47.14	7.62	60.92
60%	39.00	8.00	59.30	36.63	453.51	32.03	7.23	64.21	10.53	84.24
70%	39.00	8.00	61.07	36.99	511.50	33.10	7.45	72.28	11.91	95.26
80%	39.00	8.00	63.90	39.09	556.20	34.02	8.22	80.73	13.29	106.30
40%	39.00	10.00	56.46	37.11	407.38	30.30	7.78	60.37	7.62	76.15
60%	39.00	10.00	63.21	41.12	556.74	32.40	8.24	81.77	10.53	105.30
70%	39.00	10.00	64.95	41.50	627.34	33.45	8.47	91.88	11.91	119.08
80%	39.00	10.00	68.55	44.37	678.60	34.51	9.36	101.54	13.29	132.88
40%	39.00	12.00	62.50	43.15	492.24	30.78	8.26	68.91	7.62	91.38
60%	39.00	12.00	68.32	46.79	652.00	32.98	9.43	92.39	10.53	126.36
70%	39.00	12.00	70.05	47.19	734.58	34.02	9.67	103.78	11.91	142.90
80%	39.00	12.00	73.50	49.91	799.33	35.04	10.52	115.78	13.29	159.46
40%	42.00	8.00	56.33	34.95	354.40	31.84	6.95	50.42	8.18	65.40
60%	42.00	8.00	69.60	45.87	480.02	34.81	8.85	69.80	11.48	91.87
70%	42.00	8.00	71.48	46.28	539.32	35.94	9.09	78.28	12.93	103.46
80%	42.00	8.00	74.43	48.43	584.86	36.93	9.90	87.13	14.38	115.06
40%	42.00	10.00	59.32	38.49	436.07	32.21	7.96	64.48	8.18	81.75
60%	42.00	10.00	73.51	50.38	589.31	35.17	9.86	88.77	11.48	114.84
70%	42.00	10.00	77.25	53.29	643.52	36.31	10.79	98.94	12.93	129.33
80%	42.00	10.00	79.10	53.74	713.98	37.42	11.06	109.57	14.38	143.82
40%	42.00	12.00	65.35	44.53	526.67	32.69	8.44	73.54	8.18	98.10
60%	42.00	12.00	78.64	56.08	690.55	35.75	11.07	100.27	11.48	137.81
70%	42.00	12.00	82.22	58.84	758.63	36.85	11.94	112.84	12.93	155.20
80%	42.00	12.00	84.05	59.31	841.15	37.95	12.22	124.82	14.38	172.58
40%	45.00	8.00	71.38	49.10	384.71	35.90	9.96	56.16	9.15	73.24
60%	45.00	8.00	77.72	52.29	517.34	38.33	10.49	75.14	12.40	99.17
70%	45.00	8.00	80.80	54.48	566.63	39.37	11.33	84.45	13.93	111.40
80%	45.00	8.00	82.79	54.94	627.65	40.57	11.61	93.41	15.46	123.64
40%	45.00	10.00	74.37	52.65	473.19	36.26	10.98	71.67	9.15	91.55
60%	45.00	10.00	81.61	56.82	634.78	38.66	11.53	96.46	12.40	123.96
70%	45.00	10.00	85.46	59.79	691.76	39.85	12.50	106.22	13.93	139.25
80%	45.00	10.00	87.44	60.27	766.16	41.04	12.79	117.45	15.46	154.55
40%	45.00	12.00	80.42	58.70	571.12	36.74	11.46	81.64	9.15	109.86
60%	45.00	12.00	86.72	62.54	743.77	39.22	12.76	107.81	12.40	148.75
70%	45.00	12.00	90.41	65.36	815.12	40.37	13.67	121.04	13.93	167.10
80%	45.00	12.00	92.37	65.86	902.25	41.55	13.98	133.69	15.46	185.46

TABLE 32.1
OVERHEAD SIGN SUPPORT
LOADS AT BOTTOM OF BASEPLATE

SS (%)	span (m)	height (m)	Pdl,max (kN)	Pdl,min (kN)	Pwind (kN)	Pice.max (kN)	Pice.min (kN)	Hwind (kN)	Ht,wind (kN)	Mt,wind (kN-m)
40%	48.00	8.00	75.25	51.48	409.10	38.06	10.38	59.65	9.75	78.01
60%	48.00	8.00	89.11	63.32	531.63	41.25	13.02	81.29	13.39	107.08
70%	48.00	8.00	91.23	63.84	593.52	42.51	13.33	90.61	14.98	119.81
80%	48.00	8.00	93.34	64.35	655.41	43.78	13.64	99.92	16.57	132.54
40%	48.00	10.00	81.46	58.29	502.91	38.39	11.42	76.05	9.75	97.51
60%	48.00	10.00	93.81	68.64	649.46	41.74	14.19	102.26	13.39	133.85
70%	48.00	10.00	95.91	69.18	724.96	42.99	14.51	113.93	14.98	149.76
80%	48.00	10.00	99.38	71.76	783.16	44.15	15.43	126.06	16.57	165.67
40%	48.00	12.00	86.59	63.99	589.43	38.95	12.65	85.95	9.75	117.01
60%	48.00	12.00	98.40	73.82	765.91	42.16	15.26	116.58	13.39	160.62
70%	48.00	12.00	100.47	74.37	854.38	43.40	15.59	129.73	14.98	179.71
80%	48.00	12.00	104.25	77.27	923.27	44.61	16.55	143.48	16.57	198.80
40%	51.00	8.00	87.58	62.98	432.84	40.88	12.23	64.66	10.61	84.85
60%	51.00	8.00	93.17	65.78	563.37	43.43	13.45	86.07	14.20	113.61
70%	51.00	8.00	99.00	70.35	623.09	45.28	14.76	96.50	15.98	127.86
80%	51.00	8.00	102.64	73.04	669.54	46.53	15.74	105.96	17.65	141.20
40%	51.00	10.00	91.50	67.50	532.06	41.22	13.27	82.32	10.61	106.06
60%	51.00	10.00	97.85	71.12	688.18	43.89	14.64	108.25	14.20	142.01
70%	51.00	10.00	103.68	75.72	761.29	45.75	15.95	121.32	15.98	159.83
80%	51.00	10.00	107.26	78.35	821.28	46.98	16.91	134.01	17.65	176.50
40%	51.00	12.00	96.65	73.23	623.91	41.78	14.51	93.01	10.61	127.27
60%	51.00	12.00	102.42	76.32	811.28	44.29	15.72	123.32	14.20	170.41
70%	51.00	12.00	109.95	83.25	878.93	46.12	17.67	138.65	15.98	191.80
80%	51.00	12.00	112.13	83.87	968.21	47.42	18.04	152.43	17.65	211.80

Refer to the following sketch for the location of the load applications for the Overhead Sign Support structure.

TABLE 32.2
CANTILEVER SIGN SUPPORT
LOADS AT BOTTOM OF BASEPLATE

SS (%)	span (m)	height (m)	H _z ,wind (kN)	P _y ,dl (kN)	P _y ,ice (kN)	M _x ,wind (kN)	M _y ,wind (kN)	M _z ,dl (kN)
40%	6.00	8.00	23.58	21.62	8.52	181.31	92.59	40.99
50%	6.00	8.00	27.79	26.29	9.12	213.92	105.49	50.97
60%	6.00	8.00	31.71	26.95	9.51	245.26	116.07	52.74
70%	6.00	8.00	35.92	29.02	10.11	277.92	124.29	54.14
80%	6.00	8.00	42.09	29.68	10.50	327.26	138.26	55.12
40%	9.00	8.00	37.42	38.42	13.70	288.84	214.24	121.59
50%	9.00	8.00	43.16	44.34	14.42	334.75	242.03	148.66
60%	9.00	8.00	51.44	46.74	15.21	399.95	280.05	152.69
70%	9.00	8.00	57.32	47.73	15.80	447.03	298.59	155.79
80%	9.00	8.00	63.51	50.14	16.59	495.43	311.83	158.05
40%	12.00	8.00	53.82	60.84	19.97	417.95	409.96	284.42
50%	12.00	8.00	61.66	71.58	20.95	479.64	459.79	341.18
60%	12.00	8.00	69.23	77.32	21.74	540.13	500.61	348.27
70%	12.00	8.00	76.79	78.63	22.53	600.61	532.37	353.79
80%	12.00	8.00	84.99	79.95	23.32	666.24	559.68	357.73
40%	6.00	10.00	24.41	25.45	9.09	230.87	92.56	41.00
50%	6.00	10.00	28.33	28.71	9.48	270.04	105.49	50.97
60%	6.00	10.00	32.61	31.09	10.12	311.18	116.06	52.76
70%	6.00	10.00	36.53	31.75	10.52	350.37	124.29	54.14
80%	6.00	10.00	43.06	34.14	11.16	414.04	138.26	55.14
40%	9.00	10.00	38.09	41.46	14.61	364.35	214.24	121.59
50%	9.00	10.00	44.18	49.11	15.13	423.64	241.99	148.70
60%	9.00	10.00	52.53	51.83	15.96	505.49	280.03	152.73
70%	9.00	10.00	58.42	52.82	16.55	564.37	298.58	155.84
80%	9.00	10.00	64.67	55.54	17.39	625.23	311.82	158.1
40%	12.00	10.00	54.97	66.24	20.76	528.23	409.88	284.50
50%	12.00	10.00	62.53	80.96	21.55	603.84	459.79	341.18
60%	12.00	10.00	70.09	82.27	22.34	679.44	500.61	348.27
70%	12.00	10.00	77.66	88.93	23.12	755.05	532.37	353.79
80%	12.00	10.00	85.86	90.25	23.91	837.08	559.68	357.73
40%	6.00	12.00	25.37	29.91	9.75	282.93	92.54	41.02
50%	6.00	12.00	29.29	33.17	10.14	329.96	105.48	50.98
60%	6.00	12.00	33.64	35.86	10.83	379.74	116.05	52.77
70%	6.00	12.00	37.56	36.52	11.22	426.80	124.28	54.15
80%	6.00	12.00	44.16	39.22	11.91	503.63	138.25	55.15
40%	9.00	12.00	39.18	46.55	14.91	443.84	214.20	121.63
50%	9.00	12.00	45.34	54.51	15.92	515.41	241.96	148.74
60%	9.00	12.00	53.34	55.50	16.51	611.36	280.03	152.73
70%	9.00	12.00	59.65	58.53	17.39	684.75	298.57	155.88
80%	9.00	12.00	65.54	65.89	17.99	755.45	311.82	158.10
40%	12.00	12.00	55.84	76.60	21.36	639.04	409.88	284.50
50%	12.00	12.00	63.40	85.92	22.14	729.77	459.79	341.18
60%	12.00	12.00	70.96	93.55	22.93	820.50	500.61	348.27
70%	12.00	12.00	78.53	94.86	23.72	911.23	532.37	353.79
80%	12.00	12.00	86.73	102.23	24.51	1010.00	559.68	357.73

Refer to the following sketch for the location of the load applications for the Cantilever Sign Support structure.

